II. CLAIMS

1-18. (Cancelled).

19. (Previously Presented) A method for net shaping gear teeth of a high performance power transmission gear from a powder metal workpiece, comprising the steps of:

(a) heating a powder metal workpiece in the form of a near net shaped gear blank having gear teeth surfaces above its critical temperature to obtain an austenitic structure throughout its surfaces;

(b) isothermally quenching the workpiece at a rate greater than the critical cooling rate of its surfaces to a uniform metastable austenitic temperature just above the martensitic transformation temperature;

(c) rolling the gear teeth surfaces of the workpiece to a substantially finished outer peripheral profiled shape between opposed dies, each die having an outer peripheral powder metal gear tooth finishing surface configured to geometrically finish the powder metal surface of each tooth during rolling, while holding the workpiece at the uniform metastable austenitic temperature, the gear teeth surfaces undergoing densification, plastic deformation, strengthening and final shaping as a result of the rolling operation; and

(d) cooling the workpiece through the martensitic range to thereby harden the surfaces of the gear teeth.

20. (Previously Presented) The method set forth in claim 19 wherein step (c) includes the steps, sequentially, of:

(e) radially compacting the material in the gear teeth surface layers resulting in a collapse of the pores initially existing in the gear teeth surface regions with resulting densification of the gear teeth surface regions; and

(f) plastically deforming the gear teeth surface layers by causing lateral material flow of the gear teeth surface layers as a result of the operation of rolling in the metastable austenitic temperature range.

21. (Cancelled).

22. (Previously Presented) The method set forth in claim 19, including the steps, before step (a) of sequentially:

(e) pressing the workpiece;

(f) sintering the workpiece; and

(g) densifying the workpiece.

23. (Previously Presented) The method set forth in claim 27 wherein step (e) includes the steps, alternatively, of:

(h) single pressing the workpiece; and

multiple pressing the workpiece.

24. (Previously Presented) The method set forth in claim 27 wherein step (f) includes the steps, alternatively, of:

(h) single sintering the workpiece; and

(i) multiple sintering the workpiece.

25. (Previously Presented) The method set forth in claim 27 wherein step (f) includes the step of:

(g) sintering and hardening the workpiece in an integrated operation.

26. (Previously Presented) The method set forth in claim 27 wherein step (f) includes the step of:

(g) sintering, hardening, and carburizing the workpiece in an integrated operation.

27. (Previously Presented) The method set forth in claim 19 including the steps, before step (a) of:

(e) pressing the workpiece; and

(f) sintering the workpiece.

28. (Previously Presented) The method set forth in claim 27 including the step of:

(g) applying densifying pressure to surfaces of at least the gear tooth root and gear tooth flank regions of the pressed and sintered powder metal gear blank to establish densification in the range of 90 to 100 percent of full theoretical density to a depth of about 70 microns and up to about 1300 microns.

29. (Previously Presented) The method as set forth in claim 19 for fabricating a parallel axis gear.

30. (Previously Presented) The method as set forth in claim 29 wherein the parallel axis gear includes at least one of a spur gear, a helical gear, and a double helical gear.

31. (Previously Presented) The method as set forth in claim 19 for fabricating an intersecting axis gear.

32. (Previously Presented) The method as set forth in claim 31 wherein the intersecting axis gear includes at least one of a straight bevel gear, a spiral bevel gear, a hypoid gear, a worm gear, and a worm-wheel gear.

33-34. (Cancelled).

35. (Previously Presented) A method of producing net shaped gear teeth from a near net shape workpiece of powder metal having an initial outer peripheral contoured surface, each gear tooth having a gear tooth flank with a nominally involute surface and a root/fillet region with a trochoidal surface, the method comprising the steps of:

(a) rotatably supporting on a first axis a rolling die having an outer peripheral contoured surface extending between generally parallel spaced lateral surfaces transverse to the first axis, the rolling die including a plurality of teeth, each gear tooth including a tooth flank with opposed involute surfaces and a tooth tip surface;

(b) rotatably supporting on a second axis distant from and parallel to the first axis a near net shape powder metal workpiece having an initial outer peripheral contoured surface and including a plurality of gear teeth, each gear tooth having a tooth flank with a nominally involute

surface and a root/fillet region with a trochoidal surface;

(c) advancing the rolling die in an in-feed direction generally perpendicular to the first and second axes such that the rolling die meshingly engages with the workpiece;

(d) rotating the rolling die about the first axis while engaged with the workpiece;

(e) rolling the gear teeth surfaces of the workpiece to a substantially finished outer peripheral profiled shape while engaged with the rolling die having an outer peripheral powder metal gear tooth finishing surface configured to geometrically finish the powder metal surface of each tooth during rolling, while holding the workpiece at the uniform metastable austenitic temperature, the gear teeth surfaces undergoing densification, plastic deformation, strengthening and final shaping as a result of the rolling and sliding operation;

(f) while performing step (d), maintaining continuous conjugacy between the rolling die and the workpiece with the involute surface of each tooth of the rolling die engaging the involute surface of a mating tooth of the workpiece and the tooth tip of the rolling die engaging the trochoidal root/fillet surface between adjacent mating gear teeth of the workpiece to effect material flow along the outer peripheral contoured surface;

(g) continuing to advance the rolling die in the in-feed direction thereby deforming the surface of each gear tooth flank and of a corresponding root/fillet region until a

final net shape of each gear tooth and root/fillet region is achieved; and

(h) continuing to perform all of the preceding steps with the rolling die and workpiece meshingly engaged, thereby deforming the involute and trochoidal root/fillet surfaces of all of the gear teeth of the workpiece resulting in a final net shaped gear.

36. (Cancelled).

37. (Previously Presented) The method set forth in claim 35 wherein step (e) includes the steps of:

(i) radially compacting the material in the gear teeth surface layers resulting in a collapse of the pores initially existing in the gear teeth surface regions with resulting densification of the gear teeth surface regions; and

(j) plastically deforming the gear teeth surface layers by causing lateral material flow of the gear teeth surface layers as a result of the operation of rolling and sliding in the metastable austenitic temperature range.

38. (Original) A method as set forth in claim 35 including the step, before step (c) of:

(i) advancing the workpiece in a through-feed direction parallel to the first and second axes such that the outer peripheral profiled surface of the workpiece engages the outer peripheral profiled surface of the rolling die and continues to advance until the workpiece is positioned

substantially coextensive with the rolling die in the through-feed direction.

39. (Original) A method as set forth in claim 38 wherein step (c) includes the steps of:

(i) simultaneously with step (g) after the workpiece and rolling die are substantially enmeshed, advancing the rolling die within a plane containing the first and second axes, in an in-feed direction substantially perpendicular to the first and second axes until the outer peripheral surface of the rolling die engages the outer peripheral surface of the workpiece at a near net shaped center distance establishing an initial center distance between the first and second axes when the workpiece and the rolling gear die are initially engaged; and

(j) continuing to advance the workpiece in the in-feed direction by an additional increment of center distance thereby deforming the profile surfaces of each gear tooth resulting in final net shape of the teeth.

40. (Cancelled).

41. (Previously Presented) A method of producing a full form net shaped gear from a near net shape powder metal workpiece having an initial outer peripheral contoured surface and including a plurality of gear teeth, each gear tooth having a gear tooth flank with a nominally involute surface and a root/fillet region with a trochoidal surface, the method comprising the steps of:

(a) providing a cylindrical grinding wheel having an outer peripheral surface and rotatable about an axis;

(b) dressing the grinding wheel by advancing a dressing tool into engagement with the outer peripheral surface to remove material therefrom to thereby produce a grinding wheel profile having a desired contoured outer surface;

(c) supporting on an axis which lies in a plane parallel to the plane of the grinding wheel axis but perpendicular to the grinding wheel axis a cylindrical rolling die blank having a plurality of circumferentially spaced near net shaped teeth defining an arcuate pitch length between adjacent teeth, each pair of adjacent teeth having opposed gear tooth surfaces and a common root/fillet region therebetween;

(d) advancing the grinding wheel radially toward and into engagement with the rolling die blank such that the contoured outer surface thereof engages the opposed gear tooth surfaces and the common root/fillet region between two adjacent teeth of the rolling die blank;

(e) simultaneously with step (d), rotating the grinding wheel about its axis to produce a final gear tooth profile for the opposed gear tooth surfaces and its common root/fillet region;

(f) withdrawing the grinding wheel from engagement with the rolling die blank;

(g) rotating the rolling die blank on its axis by an increment equal in arc length to the pitch between adjacent teeth thereof so that the grinding wheel is aligned with the opposed gear tooth surfaces and common root/fillet region of the next successive pair of adjacent teeth of the rolling die blank;

(h) repeating steps (d), (e), (f), and (g) until all of the teeth of the rolling die blank have been ground to the desired shape and resulting in a finished rolling die;

(i) rotatably supporting the finished rolling die on a first axis, the rolling die having an outer peripheral contoured surface extending between generally parallel spaced lateral surfaces transverse to the first axis, the rolling die including a plurality of teeth, each including a gear tooth flank with opposed involute surfaces and a gear tooth tip surface;

(j) rotatably supporting the powder metal workpiece on a second axis distant from and parallel to the first axis;

(k) advancing the rolling die in an in-feed direction generally perpendicular to the first and second axes such that the rolling die meshingly engages with the workpiece,

(l) rotating the rolling die while engaged with the workpiece;

(m) rolling the gear teeth surfaces of the workpiece to a substantially finished outer peripheral profiled shape while engaged with the rolling die having an outer peripheral powder metal gear tooth finishing surface configured to geometrically finish the powder metal surface of each tooth during rolling, while holding the workpiece at the uniform metastable austenitic temperature, the gear teeth surfaces undergoing densification, plastic deformation, strengthening, and final shaping as a result of the rolling and sliding operation;

(n) while performing step (l), maintaining continuous conjugacy between the rolling die and the workpiece with the involute surface of each tooth of the rolling die engaging the involute surface of a mating tooth of the workpiece and the tooth tip of the rolling die engaging the trochoidal root/fillet surface of a mating tooth of the workpiece; and

(o) continuing to advance the rolling die in the in-feed direction thereby deforming the surface of each gear tooth flank and of a corresponding root/fillet region until a final net shape of each gear tooth and of each root/fillet region is achieved, and

(p) continuing to perform steps (i), (j), (k), (l), (m), and (n) with the rolling die and workpiece meshingly engaged, thereby deforming the involute and trochoidal root/fillet surfaces of each tooth of the workpiece resulting in a final net shape of all of the teeth thereof.

42. (Original) The process set forth in claim 41 wherein step (e) includes the steps of:

(q) radially compacting the material in the gear teeth surface layers resulting in a collapse of the pores initially existing in the gear teeth surface regions with resulting densification of the gear teeth surface regions; and

(r) plastically deforming the gear teeth surface layers by causing lateral material flow of the gear teeth surface layers as a result of the operation of rolling in the metastable austenitic temperature range.

43. (Previously Presented) A method of producing a full form net shaped gear from a near net shape powder metal workpiece having an initial outer peripheral contoured surface and including a plurality of teeth, each having a tooth flank with a nominally involute surface and a root/fillet region with a trochoidal surface, the method comprising the steps of:

(a) rotatably supporting on first and second generally parallel spaced axes, first and second rolling dies, each having an outer peripheral contoured surface extending between generally parallel spaced lateral surfaces transverse to the first axis, each rolling die including a plurality of teeth, each tooth including a tooth flank with opposed involute surfaces and a tooth tip surface;

(b) rotatably supporting the powder metal workpiece on a third axis distant from and parallel to the first and second axes;

(c) advancing the first and second rolling dies, within a common plane generally containing the first, second, and third axes in respectively opposite in-feed directions generally perpendicular to the third axis until the rolling die meshingly engages with the workpiece,

(d) rotating the rolling dies about their associated first and second axes while engaged with the workpiece;

(e) rolling the gear teeth surfaces of the workpiece to a substantially finished outer peripheral profiled shape while engaged with the rolling die having an outer peripheral powder metal gear tooth finishing surface configured to geometrically finish the powder metal surface of each tooth during rolling, while holding the

workpiece at the uniform metastable austenitic temperature, the gear teeth surfaces undergoing densification, plastic deformation, strengthening and final shaping as a result of the rolling and sliding operation;

(f) while performing step (d), maintaining continuous conjugacy between each of the rolling dies and the workpiece with the involute surface of each tooth of each of the rolling dies engaging the involute surface of a mating tooth of the workpiece and the tooth tip of each of the rolling dies engaging the trochoidal root/fillet surface between adjacent mating teeth of the workpiece;

(g) continuing to advance each of the rolling dies in the in-feed direction thereby deforming the surface of each tooth flank and of a corresponding root/fillet region until a final net shape of each tooth and of each root/fillet region is achieved, and

(h) continuing to perform all of the preceding steps with the rolling dies and workpiece meshingly engaged, thereby deforming the involute and trochoidal root/fillet surfaces of all of the teeth of the workpiece resulting in a final net shaped machine element.

44. (Previously Presented) The method set forth in claim 43 wherein step (e) includes the steps of:

(i) radially compacting the material in the gear teeth surface layers resulting in a collapse of the pores initially existing in the gear teeth surface regions with resulting densification of the gear teeth surface regions; and

(j) plastically deforming the gear teeth surface layers by causing lateral material flow of the gear teeth surface layers as a result of the operation of rolling and sliding in the metastable austenitic temperature range.

45. (Original) A method as set forth in claim 43 including the step, before step (c) of:

(i) advancing the workpiece in a through-feed direction parallel to the first, second, and third axes such that the outer peripheral profiled surface of the workpiece engages the outer peripheral profiled surface of each of the rolling dies and continues to advance until the workpiece is positioned substantially coextensive with the rolling dies in the through-feed direction.

46. (Original) A method as set forth in claim 44 wherein step (c) includes the steps of:

(i) simultaneously with step (h) after the workpiece and rolling die are substantially enmeshed, advancing the rolling die within a plane containing the first and second axes, in an in-feed direction substantially perpendicular to the first and second axes until the outer peripheral surface of the rolling die engages the outer peripheral surface of the workpiece at a near net shaped center distance establishing an initial center distance between the first and second axes when the workpiece and the rolling gear die are initially engaged; and

(j) continuing to advance the workpiece in the in-feed direction by an additional increment of center distance thereby deforming the profile surfaces of each gear tooth resulting in final net shape of the teeth.

47. (Previously Presented) The method set forth in claim 19 wherein the root/fillet region of the gear teeth are compacted with a rolling die having a tip radius from about 0.014 to about 0.018 inches.